Kognitive Neurobiologie
(= Grundlagen der Neuro- und Verhaltensbiologie III)

XII Communication

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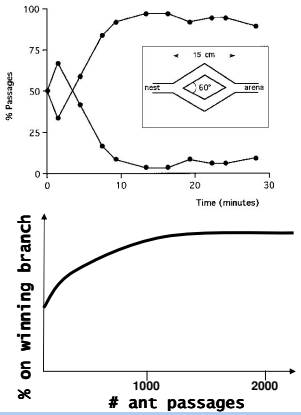
Overview

- Swarm intelligence and "stigmergy"
- Recruitment
  - Ritualization: Tandem walking, pheromones etc.
  - Bee dance
- "Altruism" and the evolution of cooperativity
- Vervet monkey alarm calls
- Facial expressions

Trail Formation

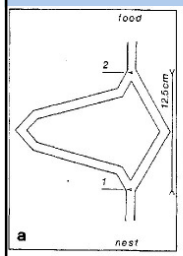
Deneubourg et al. *J. Insect Behavior* 3:159-168, 1990

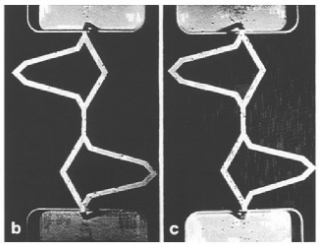


- Bridge with two equidistant path alternatives between nest and foraging arena.
- Stable path preference forms within about 10 minutes
- Model
  - ants prefer path with stronger pheromone marking
  - each ant drops pheromone when passing

"Self-organized shortcuts in the Argentinan Ant"

S. Goss et al., *Naturwissenschaften* 76:579-581,1989

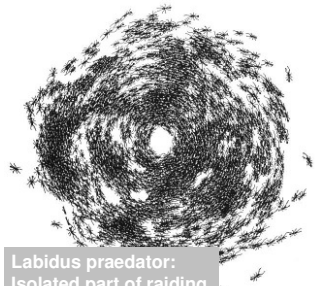




Iridomyrmex humilis
(from: www.the-piedpiper.co.uk)

- fig b: 4 minutes after placement, ants walk on both branches
- fig c: 8 minutes after placement, ants walk almost exclusively on shorter branch.

Swarm Intelligence



Labidus praedator: Isolated part of raiding colony circling until death (1.5 days)

Onychomyrmex sp., Collaborative moving of a large prey

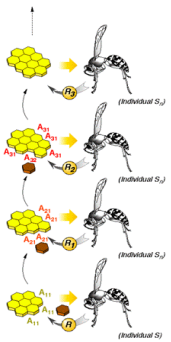
Pictures from: Hölldobler B, Wilson EO, *The Ants*, Springer 1990, p586

Examples of Wasp Nests

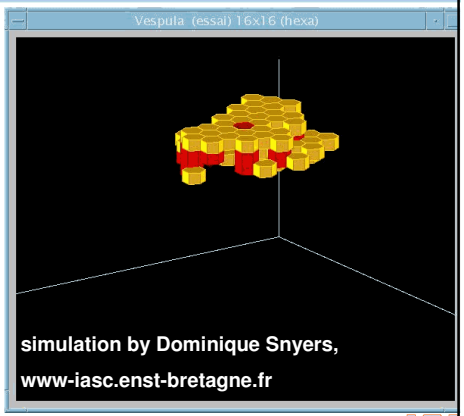
Polistes sp.

"Stigmergy": collective nest building in wasps

Theraulaz, Bonabeau: *J. Theoretical Biology* 177:381-400,1995



local building rules



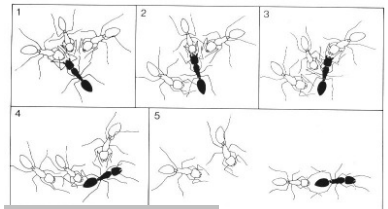
Ritualization: From individual to mass recruitment

Species	Recruitment	Guidance	number recruited
Camponotus sericeus	food offering	tandem running	individual
Camponotus socius	waggle display	pheromone plus scout	small group (10-20)
Formica fusca	waggle display + food offering	pheromone (no scout required)	continuous stream
Solenopsis gemminata	pheromone	pheromone	mass recruitment

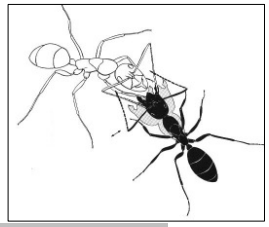
The trail pheromone, initially only used to giude the scout back to the source, takes additional functions:

- Guiding other ants to source
- Recruiting (allerting) ants at nest

Ritualization: From individual to mass recruitment



Camponotus sericeus: Food offering and tandem walking



Camponotus socius: Waggle display for recruitment

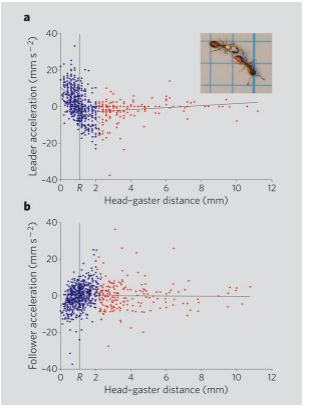
Pictures from: Hölldobler B, Wilson EO, *The Ants*, Springer 1990, p275, 277

"Teaching in Tandem Running Ants"

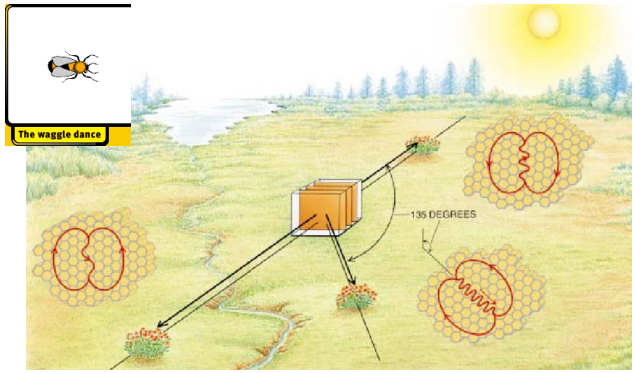
Franks NR, Richardson T, Nature 439:153 (2006)

- Temnothorax albipennis
- In tandem-running, a recruiting ant leads a recruited ant who is touching the leader's hind-legs with her antennae.
- If gap between ants grows, leader slows down (Fig a, blue dots) while follower speeds up (Fig b, blue dots)
- For gaps larger than twice the antennal read, leader stops while follower loops around (red dots)

movie



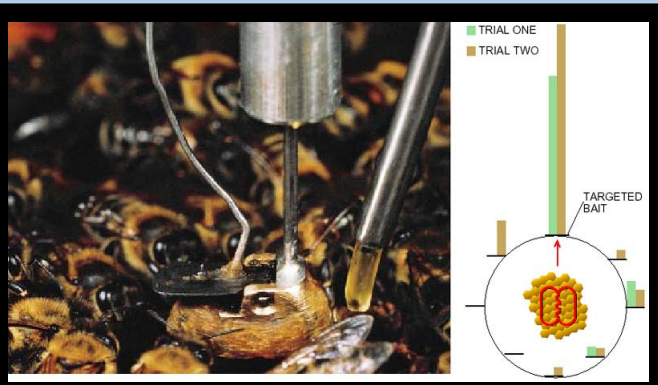
Recruitment: The honey bee dance "language"



http://www.ling.upenn.edu/courses/Spring_2003/ling001/13a.html

Recruitment by "Robot Bee"

Michelsen et al., *Behav, Evol, Sociobiol* 30, 143-150, 1992



http://www.ling.upenn.edu/courses/Spring_2003/ling001/13a.html

Waggle Dance Communication

- Information encoding
  - Dance direction while waggle of abdomen
  - Dance direction rotates with time (sun azimuth)
  - Wing vibration (humming sound)
  - Comb vibration
  - Food samples (smell and taste)
- Function
  - Recruitment by robot bee is possible
  - Colonies with horizontal combs (disturbed dance) are only mildly impaired
  - Symbol
    - Dance direction is not goal direction
    - High information contend (angle, distance)
    - Content influences behavior long after communication
- Still, the waggle dance is a stereotyped behavior

The Evolution of Altruism and the Prisoner's Dilemma

pay-off matrix		partner 1: cheat	partner 1: cooperate
partner 2	cheat	q_{00} / q_{00}	q_{10} / q_{01}
partner 2	cooperate	q_{01} / q_{10}	q_{11} / q_{11}

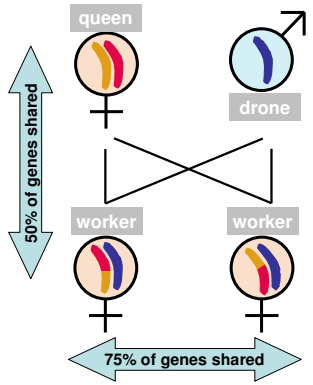
- Strategies. Pay-off depends on probaility p of partner cooperation
  - always cooperate: Payoff A = $(1-p)\ q_{10} + p\ q_{11}$
  - always cheat: Payoff B = $(1-p)\ q_{00} + p\ q_{01}$
- Individual fitness maximized by "cheating" if B > A
- "Species fitness" maximized if both cooperate (2 p11 > p01+p10)
- Cooperation is not an "Evolutionarily Stable Strategy" (ESS). If practiced, it can be "invaded" by mutants using an "always cheat"-strategy

The Evolution of Cooperation: How to overcome the prisoner's dilemma.

- Iterated prisoner's dilemma (Axelrod)
  - Tit-for-tat (*Wie du mir, so ich dir*) is EES
  - Requires individual recognition
- Local interactions in spatial populations (Sigmund)
  - Interacting partners are likely to use same strategy
  - Stable local populations of cooperators evolve
- Handicap principle (Zahavi)
  - Signals can be trusted only if they are "expensive". E.g., antlers truely signal health, because week deer won't grow beautiful antlers.
- Kin selection (Darwin, Hamilton)
  - Altruism directed towards kin increases fitness of underlying genes ("egoistic gene").

Evolution of Cooperativity: Kin selection in haplo-diploic systems

- Queen, workers: diploid, drone: haploid
- Workers share all their paternal genes and half of maternal genes, resulting in relatedness of 75%
- workers related to own female offspring: 50%
- optimal gene reproduction by supporting queen in generating sisters, not by generating own children

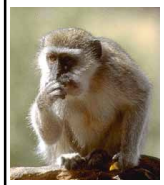


Evolution of Cooperativity: Social Hymenopera

- Sociality frequent in hymenoperans with haplodiploid reproduction system (bees, wasps, ants).
- Problems
  - Theory does not explain sociality in other insect groups (termites), nor lack of sociality in some hymenopterans (e.g., Ichneumonidae).
  - Relatedness numbers change if multiple drones mate with one queen or if multiple queens are present.
  - Mechanism of kin recognition may be required.

Vervet Monkey Alarm Calls

RM Seyfarth, DL Cheney, P Marler, Science 210, 1980



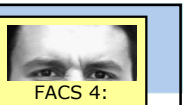
Cercopithecus aethiops

(from http://cogsci.ucsd.edu/~batali/vervets.html)

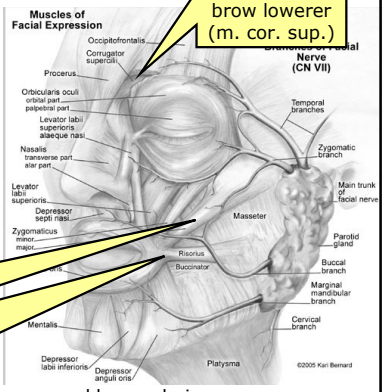
- **Snake** warning call:
  Reaction: Vervets stand up on hind legs in the open and look around on the ground - to find the snake.
- **Leopard** warning call:
  Reaction: Vervets run up to the top of the nearest tree, where the heavy leopard can't follow them (note that eagles and snakes could).
- **Eagle** warning call:
  Reaction: Vervets run into a bush or under the lower branches of a nearby tree.
- Learning the meaning of an eagle call:
  - infants produce call for raptors as well as non-raptors (e.g., vulture, heron, goose, pigeon etc.)
  - adults produce call mostly for raptors and rarely for other, similar birds (stork, vulture)

Facial Expressions

- Human face contains a large number of muscles specialized for the production of facial expressions.
- Actions of individual movements classified in "facial action coding system", FACS.
- (FACS pictures from http://www.cs.cmu.edu/afs/cs/project/face/www/Facial.htm)



FACS 4: brow lowerer (m. cor. sup.)



FACS 12: lip stretcher (m. zyg. maj.)

FACS 20: lip stretcher (m. risorius)

www.kbernardmi.com

Facial Expressions and Emotion

P. Ekman: Facial expressions. In T. Dalgleish, M. Power: *Handbook of Cognition and Emotion*. John Wiley 1999, pp45-60

- Ask subjects to match pictures to named emotions shown on a list.
- Interculturally consistent response (21 countries)
  - happiness
  - surprise
  - fear
  - anger
  - disgust
  - sadness